Dating the Ngandong Humans

Efforts to date the Ngandong human remains are critical to regional and global aspects of human evolution, especially with regard to the current debate over the emergence of modern human morphologies and their relevance, if any, to the Pleistocene and recent skeletal forms of Australian aborigines. We see, however, problems with the recent report by Carl C. Swisher *et al.* (*1*).

We consider the Solo high terrace to represent a melange of materials reworked from different levels, sites, and ages. The human remains, despite their glossy exterior caused by repeated casting, are dark brown and black, dense, and ceramic-like in texture—in contrast to the museum and in situ faunal remains which are generally grey with bluish manganese staining, with a crumbly texture (*2*). It is therefore likely that the human and faunal remains originally fossilized in different environments.

The faunal elements were analyzed by U-series and electron spin resonance (ESR) dating. U-series dating is based on the measurement of the parent U isotopes and the daughter Th and on the assumption that the material does not contain any initial Th. ESR age estimations are derived from the determination of all possible radioactive sources and the estimation of ESR response to laboratory irradiation (*3*). A major problem for both techniques is that modern teeth do not contain any U, while fossil teeth may contain considerable amounts. The Javan specimens have high concentrations. It is not known, however, how U migrates into teeth. The general assumption is that the correct age of a specimen normally lies between the estimates of two hypothetical models, early (rapidly within a short time interval) uptake (EU) and linear (continuous) uptake (LU). The combination of ESR and U-series dating allows the simulation of U uptake (*4*), but requires that the apparent U-series age is younger than the ESR age.

The ESR age calculations in the report by Swisher *et al.* (*1*) are not accompanied by the most basic analytical values, so they cannot be assessed. The unknown U uptake is accounted for by the calculation of EU and LU ages. The most evident problem lies in the fact that the U-series results are older than the ESR ages. This is explained in the report by U leaching. Nearly all detailed studies of bones and teeth have shown that the predominant process of U migration is from the environment into the biological material. Leaching does occur, but usually to a minor extent with respect to the total U concentration and only at the surface. The general behavior of U migration affects both ESR and U-series results.

In order to test the leaching hypothesis, experiments were carried (*1*) out on enamel samples from which some surface layer was removed. The interior parts were found to be apparently younger than the outer parts. The same results can be readily explained, however, by U diffusion into the tooth. Uranium arrives at the surface first and progresses slowly, deeper into the enamel. This leads to higher U concentrations as well as apparently older U-series ages at the surface. The same process applies to dentine but, because of higher U mobility through dentine, these ages tend to be older. If the U-series data of dentine sample 94NG-T2, containing 131 ppm of U, result from leaching that happened yesterday, about 120 ppm must have been lost. If there was some delay in the original U uptake or the leaching started further back in time (or it was a continuous process, or both), then the amount of leached U must have been considerably higher. Uranium leaching on such a scale seems unlikely. Furthermore, any such leaching would lead to ESR age estimates younger than the EU-determined age of about 27,000 years. In spite of the postulated leaching process in both dentine and enamel, LU age results are presented in the report (*1*) as if they were meaningful. Thus the ESR results are likely to be erroneous.

Our concern that the faunal elements found at the site are not necessarily of the same age as the hominid remains is supported by the gamma spectrometric results on the hominids [unpublished results that are discussed in a Research News article by Ann Gibbons (13 Dec., p. 1841)], which are considerably older than the values reported here and elsewhere (*5*) on the faunal material.

Recently, Swisher and Curtis and their colleagues described the Javan lineage leading to Ngandong as *Pithecanthropus* (*6*) rather than *Homo*. Perhaps they will soon modernize their species taxonomy as well, from *erectus* to *sapiens*.

Ngandong morphology relates in detailed features and patterns to the earliest Australians and their living descendants (*7*, *8*), and they represent the only known later Pleistocene morphology from Indonesia. Even if the Ngandong humans proved to be only 27,000 years old, they might not have Indonesian descendants, but they must have ancestors who would still be excellent candidates for the migrations from Southeast Asia that formed the basis of the earliest Australian population. If other, more gracile or modern-looking people followed and mixed with them (*8*), then they all must have been the same biological species, that is, *Homo sapiens*.

In Java, apart from continued efforts to solve its human chronology, what is needed is less taxonomy and more comparative anatomy, one that reflects the great variability in the living as well as past human populations of the region.

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7 January 1997; accepted 30 April 1997

Response: With regard to the fossils from the Solo High Terrace at Ngandong, Java—the available published evidence based on similarities of bone chemistry [references 19 to 21 in (*1*)], the internal consistency of published U-series and ESR dates (as well as dates from Sambungmacan and Jigar) [(*1*), and references therein], the recognition of a "Ngandong Fauna" that is unique in time between older and younger Javanese faunas (*2*), and our observations on the preservation of the hominid and nonhominid fossils in the laboratory and in the field (*1*) indicate that these hominid and nonhominid fossils represent a single fauna. Bartstra *et al.* conclude [(3), p. 330]:

> Eye witnesses of the original [1930s] excavations have never doubted that the Ngandong [hominid] skulls were contemporaneous with the excavated fauna. They all maintain that the state of preservation of the [hominid] skulls were comparable to that of the associated faunal remains, and that the distribution of the skulls over the terrace area leaves no doubt as to an in situ position (for example, von Koenigswald, 1951).

In our study (*1*), we concur with the conclusions of Bartstra *et al.* (*3*) and agree that a mechanism of selectively reworking and concentrating 15 hominids of one age into a site the size of Ngandong, without

reworking older faunal elements as well, is taphonomically difficult to explain color variations, as well as variations in the apparent hardness of some of the hominid and nonhominid fossils from Ngandong, are acknowledged, but we disagree that these variations are unique to either the hominid or the nonhominid faunal elements, nor do these features provide any information concerning the relative age of the fossils. We know of no published evidence that indicates that the Ngandong hominids and nonhominid fauna are of different age.

Our study (*1*) was designed to determine which model of uranium uptake or loss in teeth could be correct, given the data at hand. Grün and Thorne account for our observation of apparently older ages in the outer layers of the enamel as an expected result of gradual inward diffusion of U into the enamel, while the older ages for dentine are seen as a result of the higher mobility of U in it. But Grün and Thorne are describing a model (of either early or continuous uptake) which must always result in U-series ages that (as they themselves note) are younger than ESR ages of the associated enamel. This problem has prompted us to invoke a less conventional, but not entirely novel suggestion of late U loss. This model has in fact been used previously by Bahain *et al.* (*4*) to account for U-series ages older than LU ESR ages. The model of Grün and Thorne would also be expected to lead to inward-decreasing gradients of U concentration in tooth enamel. Our analyses of stripped teeth suggest that this was the case for one of our samples, but not the other two. Such gradients would not be a requirement of our model, although they are permitted (as long as this gradient was developed earlier in the burial history of the tooth and before surficial loss of U).

Grün and Thorne conclude that our ESR results are probably erroneous. The ESR dates presented in our report however, are remarkably homogeneous: EU ages, for example, agree to within about 7%, including ages from samples whose U concentration varies by a factor of 30 (from 0.5 to 15.9 ppm). Thus, it is likely that all the samples were deposited over a short time interval whose exact chronology depends on the U uptake history. Previous studies of the deposits and fossils at Ngandong have also proposed a late Pleistocene age for the site on the basis of less comprehensive data than that presented in our report.

Our results are basically in agreement with previously published U-series dates on bone (*3*). We are, however, aware of two unpublished gamma spectrometric dates on Ngandong and Sambungmacan hominids mentioned in the Research News article by Ann Gibbons. It is our understanding, that these particular dates were made 5 years ago by a less reliable methodology than we have used, and the results of this study have not been published. We look forward to having the opportunity to compare these results with our own.

Finally, Grün and Thorne suggest that the use of the genus *Pithecanthropus* in a 1994 report by Swisher *et al.* (*5*) somehow makes the science in our more recent report (*1*) antiquated. The uses of the genera *Pithecanthropus* and *Meganthropus* for some of the Javanese hominids are still widely used by many Indonesians (including our Indonesian co-authors on the 1994 paper) as well as other anthropologists worldwide. While the names *Pithecanthropus* and *Meganthropus* were discussed in the 1994 report (*5*), it stated that these names are considered by most workers to be part of the *Homo erectus* hypodigm. To infer, because of that usage, that we, in our recent paper, need to modernize our taxonomy by referring *H. erectus* fossils to *H. sapiens* may be an opinion of Grün and Thorne, but it contradicts the species designation of the Javanese fossils not only from our own point of view (*6*), but in the opinions of our Indonesian colleagues as well as most recent published studies of the Javanese hominids (*7*).

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20 February 1997; accepted 30 April 1997